

CERTIFICATION

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Dated this:

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**Method for protecting a motor vehicle component against
manipulation in a control device, and control device**

Specification

This invention relates to a method for protecting at least one motor vehicle component against manipulation in a control device, and a control device.

In motor vehicles, control devices, such as for example the engine control device or the transmission control device, are currently used to control individual motor vehicle components. The information which is required for operating these control devices, such as programs and data, are stored encrypted or unencrypted in memory modules (E²PROM, flash and the like). The encryption process is independent of a fixed hardware combination of modules and is generally stored in a rewritable storage medium.

The disadvantage of these control devices and of the programs used is that individual memory modules can be replaced or the data on the memory modules can be overwritten via a diagnosis interface or via direct access to the memory module. The replacement of a memory module or overwriting of the data and programs stored on this memory module can lead to the motor vehicle components operating with other characteristics. This is done for example in so-called chip tuning in which the memory modules which are assigned to the engine control device are replaced or the programs and data stored on these memory modules, such as characteristics, are changed. As a result, the output and/or the torque of the engine can be increased for example. If this manipulation is done without adapting the other motor vehicle components, such as the oil cooler, turbocharger, or brakes, damage to these motor vehicle components and safety-critical states can occur.

The object of this invention is therefore to devise a control device for motor vehicle components and a process for protection against manipulation of a control device, in which replacement of a memory module and changing of the data on the memory module are not possible without affecting the operability of the control device or at least diagnosing the change and optionally displaying it.

The invention is based on the finding that this object can be attained by the data and programs which are necessary for operation of the control device being stored in different memories.

The object of the invention is therefore attained by a process for protection against manipulation in a control device for at least one motor vehicle component, the code necessary for operation of the control device being divided into at least one master code which comprises information essential for operation of the control device, and at least one sub-code which comprises additional information for operation of the control device, at least the master code being stored in the microcomputer and the master code monitoring the manipulation of the sub-code.

By dividing the code which is necessary for operation of the control device, on the one hand the part which for example must be reprogrammed or updated during repairs can be made accessible without the part which contains information which is essential for operation of the control device having to be accessible. Furthermore, by dividing the code, the code can be stored in different memories; this entails an increase in security against manipulation. The master code may for example constitute the actual control program which comprises the computation of engine load and rpm and the actuating variables and outputs with access to characteristics and control signal generation for connected actuators of the control device. The sub-code may then contain the program for measures which improve exhaust and comfort, for example. In addition or as an alternative the two codes may contain data.

By preference the master code is stored in a read-protected OTP (one-time-programmable) area of the microcomputer which is writable only once. With this, on the one hand-unauthorized-alteration of the master code is impossible and on the other hand copying of the software which is necessary for operation of the control device can be avoided.

The sub-code can be stored in a rewritable area of the microcomputer or in a rewritable area of an external memory module. In this way the sub-code can be updated or reprogrammed. However, the monitoring function against manipulation contained in the master code prevents unauthorized alteration of the sub-code.

Furthermore, the object underlying the invention is attained by a control device for a motor vehicle component which comprises at least one microcomputer (μ C) and at least one memory module, the code which is necessary for operation of the control device being divided into at least one master code which comprises information which is essential for operation of the control device, and at least one sub-code which comprises additional information for operation of the control device, and at least the master code being stored in the microcomputer and the master code containing a software function module for detection of manipulation within the sub-code.

The software function module can comprise for example linear or CRC checksum formation, hash value formation or an encryption process.

By preference at least one part of the sub-code is stored encrypted on a rewritable area and the master code is used to generate a key for decryption. The part of the sub-code which is stored encrypted can for example constitute a fingerprint.

Features and details which are described in conjunction with the process as claimed in the invention apply accordingly to the control device as claimed in the invention and vice versa.

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The invention will be described in greater detail below with the aid of possible embodiments illustrated in the attached drawings in which:

FIG. 1 shows a schematic block diagram of one embodiment of the control device as claimed in the invention; and

FIG. 2 shows a schematic block diagram of another embodiment of the control device as claimed in the invention.

FIG. 1 shows one embodiment of the control device as claimed in the invention. The configuration of control devices, such as for example engine control devices, has been known for a long time from the prior art, so that it is detailed only to the extent necessary for the understanding of the invention. The control device 1 in this embodiment comprises a microcomputer μC , a flash memory 2 and an EEPROM (E^2 PROM) 3. The flash memory 2 and the E^2 PROM 3 each have an OTP area 21, 31. The latter are preferably configured not to be read-protected. There is also an OTP area 11 in the μC .

The memory modules flash 2, E^2 PROM 3 in this embodiment are provided with identification numbers ID which are specific to the module. They are generally written at the manufacturer of the module and are stored in the OTP area 21, 31 of the individual modules.

In the process of manufacturing the control device, when the control device is started up for the first time the IDs of the individual memory modules 2, 3 are read out by the microcomputer μC and are stored in the OTP area 11 of the μC which area is writable only once. Starting from this time, operation of the control device 1 is only possible in conjunction with the IDs of the external memory modules 2, 3, which IDs are known to the μC .

With each additional start-up of the control device 1, the μ C again reads out the ID of all of the memory modules 2, 3 connected to it. In a comparison unit these current IDs may then be compared to the original identifiers which are stored in the OTP area 11 of the μ C. If it is established in this comparison that one of the IDs does not agree with one of the original IDs, the control device is prevented from operating or at least the change is diagnosed and optionally displayed.

The code for operating the control device is divided into a master code (MC) and a sub-code (SC). The master code MC contains elementary, essential functionalities for operating the control device, for example the program for generating signals for the connected actuators (not shown) of the control device or the program for computing the actuating variables and outputs. The master code MC can furthermore comprise data. In the sub-code SC additional programs and data are contained. The control device can only operate using both codes, MC and SC. In the illustrated embodiment, the sub-code SC is contained in a rewritable area of the flash memory 2. The master code MC is contained in the OTP area 11 of the microcomputer μ C. The master code is preferably protected against read-out by way of contact-making. This can be achieved either physically by failure of a transistor channel or by circuit engineering. The sub-code SC in contrast to the master code MC can be modified or overwritten. This allows updating of the sub-code or reprogramming.

Furthermore the μ C has an identification number μ C-ID. It is also stored in the read-protected OTP area of the μ C. In the E²PROM other data for operating the control device are stored in a rewritable area. These data may for example constitute adaptation values and idle rpm for an engine control device.

When the control device is initialized, the microcomputer μ C learns the identification numbers which have been stored in the OTP area 21, 31 of the memory modules 2, 3 and which

thus cannot be changed, and stores them in the OTP area of the microcomputer μ C which can also optionally be configured as read-protected.

From this time on, the memory modules 2, 3 which are connected to the microcomputer are known to the microcomputer μ C via their ID.

In addition, the IDs of the memory modules stored in the microcomputer can also be used for encryption of data or programs. Thus, the data stored on the E²PROM can be encoded for example by a symmetrical encryption process in which the key comprises at least part of the ID of at least one of the memory modules 2, 3. In an engine control device the E²PROM can store for example learned values, production data, and adaptation values. Basically all symmetrical encryption processes which allow incorporation of an identifier which is specific to the control device are suited for encryption. Preferably the data of the E²PROM are encrypted by a key which in addition or as an alternative to the ID of the external memory modules comprises the ID of the microcomputer μ C. This effects encryption which is specific to the control device and which makes it impossible to replace the E²PROM or overwrite the data stored on it or prevents operation of the control device after such manipulation. The key is preferably stored in the RAM of the microcomputer μ C. In this way the key is generated each time the control device boots up with the incorporation of an identifier which is specific to the control device (for example the ID of the μ C and optionally the IDs of the memory modules) and thus the key is specific to the control device.

Furthermore the sub-code SC can be stored wholly or partially encrypted on the flash memory 2. For this encryption the ID of the individual memory modules or of the microcomputer or part of this ID can also be integrated into the key. The decryption of the data in the sub-code is done by the master code. Since the latter is stored in a read-protected area of the microcomputer, read-out of the program and thus copying of the software can be prevented.

Monitoring of the sub-code relative to manipulation which is ensured by the μ C in the master code can also take place by way of processes other than encryption. Thus, as an alternative or in addition, linear/CRC checksum formation or hash value formation can be used. To detect completed manipulation of the data and optionally of parts of the sub-code, linear checksums are formed for example over selected areas and the result which has been encrypted as a fingerprint is placed in the sub-code. The master code in control device operation, for example when there is a signal on the terminal 15, over the same predefined area computes the comparison value (for example, linear checksum) and checks it against the decrypted reference value which has been stored encrypted in the sub-code. The type of manipulation detection may be selected arbitrarily.

After detecting manipulation, the master code initiates measures which may lead to control device failure.

FIG. 2 shows another embodiment of the control device as claimed in the invention. In this embodiment the memory modules 2 and 3 are integrated into the microcomputer μ C. The μ C here has an embedded flash memory, the E²PROM being emulated. This configuration of the control device does have the advantage that replacement of the memory modules can be reliably prevented, in any case the data in the emulation of the E²PROM can be overwritten only block by block.

The process for protection against manipulation takes place in this control device with an internal memory essentially analogous to the one described in the foregoing for control devices with external memories. Here in particular the data of the emulated E²PROM can be stored encrypted and can be decrypted by a key which comprises at least one individual identifier of the control device, such as the μ C-ID and/or the flash ID. Likewise the encrypted data or fingerprints contained in the sub-code which is stored in the flash memory of the μ C can be decrypted by the

master code. In this instance preferably an identifier which is specific to the control device is also integrated in the key.

The invention is not limited to the described embodiments. Thus the identifier of the individual memory modules can be for example the date of manufacture of the control device. This may prevent manipulation during the warranty period.

The control device for the purposes of this invention can constitute for example an engine control device, a transmission control device or a combination instrument.

A large number of advantages can be achieved compared to conventional control devices with the process as claimed in the invention and the control device as claimed in the invention.

With the control device as claimed in the invention, replacement of one or more modules can be reliably prevented since operation of the control device can be prevented by this replacement. It is not possible to read out a part of the program or data which is essential for operation of the control if this part is stored in a read-protected OTP area. Thus copying and modification of the software can be prevented. Access to confidential data via contact-making with the module is not possible either if they are stored in the read-protected OTP area of the μ C.

The control device can be protected against manipulation especially reliably by its being able to run only in the combination of the master code and sub-code. Changing the sub-code which is stored in the reprogrammable, optionally external memory, for example the flash memory, without adapting the master code leads to control device failure. Furthermore, data, which are stored for example on an E²PROM, can be encrypted in a manner specific to the control device. The decryption of these data can also be made dependent on the identifier of the control device. Additional security can be achieved by the encryption and decryption being made dependent on the combination of the individual modules with the IDs which are known to the μ C.

In summary, it can therefore be stated that by dividing the codes into a master code and a sub-code the manipulation of control devices, such as for example chip tuning in engine control devices, can be reliably prevented.